

CLAIMS

What is claimed is:

1. A method of fabricating a semiconductor device, comprising:
forming a ferroelectric capacitor above a semiconductor body;
5 forming a multilayer hydrogen barrier along at least a portion of a side of the ferroelectric capacitor, the multilayer hydrogen barrier comprising nitrided aluminum oxide and silicon nitride.
2. The method of claim 1, wherein forming the multilayer hydrogen
10 barrier comprises:
forming an aluminum oxide material along at least a portion of a side of the ferroelectric capacitor; and
nitriding at least a portion of the aluminum oxide material.
- 15 3. The method of claim 2, wherein forming the aluminum oxide material comprises performing an atomic layer deposition process.
4. The method of claim 2, wherein nitriding at least a portion of the
aluminum oxide material comprises performing a plasma nitridation process that
20 exposes at least a portion of the aluminum oxide material to a nitrogen-containing plasma.
5. The method of claim 2, wherein nitriding at least a portion of the
aluminum oxide material comprises performing a thermal nitridation process in a
25 nitrogen-containing ambient.
6. The method of claim 5, wherein forming the multilayer hydrogen
barrier further comprises forming silicon nitride material over at least a portion of
the aluminum oxide material, and wherein the thermal nitridation process is
30 performed *in-situ* with formation of the silicon nitride material.

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7. The method of claim 2, wherein forming the multilayer hydrogen barrier further comprises forming silicon nitride material over at least a portion of the aluminum oxide material, and wherein forming the silicon nitride material
5 comprises:

performing a high density plasma deposition process to form a first silicon nitride layer over at least a portion of the aluminum oxide material; and

forming a second silicon nitride layer over at least a portion of the first silicon nitride layer, the second silicon nitride layer comprising a low silicon-
10 hydrogen SiN material having an FTIR figure of merit value of about 0.05 or less, wherein the FTIR figure of merit is calculated as (Si-H absorbance) / (N-H absorbance x 1.4).

8. The method of claim 7, wherein forming the second silicon nitride
15 layer comprises performing a plasma enhanced chemical vapor deposition process to form the low silicon-hydrogen SiN material over at least a portion of the first silicon nitride layer.

9. The method of claim 7, wherein the low silicon-hydrogen SiN
20 material has an FTIR figure of merit value of about 0.04 or less.

10. The method of claim 7, wherein the low silicon-hydrogen SiN material has an FTIR figure of merit value of about 0.03 or less.

25 11. The method of claim 7, wherein nitriding at least a portion of the aluminum oxide material comprises performing a plasma nitridation process that exposes at least a portion of the aluminum oxide material to a nitrogen-containing plasma.

12. The method of claim 1, wherein forming the multilayer hydrogen barrier comprises:

forming a nitrided aluminum oxide material along at least a portion of a side of the ferroelectric capacitor, and

5 forming silicon nitride material over at least a portion of the nitrided aluminum oxide, wherein forming the silicon nitride material comprises:

performing a high density plasma deposition process to form a first silicon nitride layer over at least a portion of the nitrided aluminum oxide; and

10 forming a second silicon nitride layer over at least a portion of the first silicon nitride layer, the second silicon nitride layer comprising a low silicon-hydrogen SiN material having an FTIR figure of merit value of about 0.05 or less, wherein the FTIR figure of merit is calculated as (Si-H absorbance) / (N-H absorbance x 1.4).

13. The method of claim 12, wherein forming the second silicon nitride layer comprises performing a plasma enhanced chemical vapor deposition process to form the low silicon-hydrogen SiN material over at least a portion of
20 the first silicon nitride layer.

14. The method of claim 12, wherein the low silicon-hydrogen SiN material has an FTIR figure of merit value of about 0.04 or less.

25 15. The method of claim 12, wherein the low silicon-hydrogen SiN material has an FTIR figure of merit value of about 0.03 or less.

16. A method of forming a hydrogen barrier to protect ferroelectric capacitors in a semiconductor device, the method comprising:

forming a nitrided aluminum oxide material along at least a portion of a side of a ferroelectric capacitor; and

forming silicon nitride material over at least a portion of the nitrided aluminum oxide.

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17. A method of fabricating a semiconductor device, comprising:

forming a ferroelectric capacitor above a semiconductor body;

forming an aluminum oxide material along at least a portion of a side of the ferroelectric capacitor;

10 forming a first silicon nitride layer over at least a portion of the aluminum oxide material; and

forming a second silicon nitride layer over at least a portion of the first silicon nitride layer, the second silicon nitride layer comprising a low silicon-hydrogen SiN material having an FTIR figure of merit value of about 0.05 or less,

15 wherein the FTIR figure of merit is calculated as (Si-H absorbance) / (N-H absorbance x 1.4).

18. The method of claim 17, wherein forming the second silicon nitride layer comprises performing a plasma enhanced chemical vapor deposition process to form the low silicon-hydrogen SiN material over at least a portion of the first silicon nitride layer.

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19. The method of claim 17, wherein the low silicon-hydrogen SiN material has an FTIR figure of merit value of about 0.04 or less.

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20. The method of claim 17, wherein the low silicon-hydrogen SiN material has an FTIR figure of merit value of about 0.03 or less.

21. The method of claim 17, wherein forming the first silicon nitride layer comprises performing a high density plasma deposition process to form a first silicon nitride material over at least a portion of the aluminum oxide material.

5 22. The method of claim 17, further comprising nitriding at least a portion of the aluminum oxide material prior to forming the first silicon nitride layer.

23. A method of forming a hydrogen barrier to protect ferroelectric capacitors in a semiconductor device, the method comprising:

10 forming an aluminum oxide material along at least a portion of a side of a ferroelectric capacitor;

forming a first silicon nitride layer over at least a portion of the aluminum oxide material; and

15 forming a second silicon nitride layer over at least a portion of the first silicon nitride layer, the second silicon nitride layer comprising a low silicon-hydrogen SiN material having an FTIR figure of merit value of about 0.05 or less, wherein the FTIR figure of merit is calculated as (Si-H absorbance) / (N-H absorbance x 1.4).

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24. A semiconductor device, comprising:

a ferroelectric capacitor formed above a semiconductor body; and

a hydrogen barrier formed along at least a portion of a side of the ferroelectric capacitor, the hydrogen barrier comprising:

25 a nitrided aluminum oxide material formed along at least a portion of the side of the ferroelectric capacitor; and

a silicon nitride layer formed over the nitrided aluminum oxide material.

25. The semiconductor device of claim 24, wherein the silicon nitride layer comprises a low silicon-hydrogen SiN material having an FTIR figure of merit value of about 0.05 or less, wherein the FTIR figure of merit is calculated as (Si-H absorbance) / (N-H absorbance x 1.4).

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26. The semiconductor device of claim 25, wherein the low silicon-hydrogen SiN material has an FTIR figure of merit value of about 0.04 or less.

27. The semiconductor device of claim 25, wherein the low silicon-hydrogen SiN material has an FTIR figure of merit value of about 0.03 or less.

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28. The semiconductor device of claim 24, wherein the silicon nitride layer comprises:

a first silicon nitride layer formed over at least a portion of the nitrided aluminum oxide material; and

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a second silicon nitride layer formed over at least a portion of the first silicon nitride layer, the second silicon nitride layer comprising a low silicon-hydrogen SiN material having an FTIR figure of merit value of about 0.05 or less, wherein the FTIR figure of merit is calculated as (Si-H absorbance) / (N-H absorbance x 1.4).

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29. The semiconductor device of claim 28, wherein the low silicon-hydrogen SiN material has an FTIR figure of merit value of about 0.04 or less.

30. The semiconductor device of claim 28, wherein the low silicon-hydrogen SiN material has an FTIR figure of merit value of about 0.03 or less.

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31. A hydrogen barrier for protecting ferroelectric capacitors in a semiconductor device, comprising:

a nitrided aluminum oxide material formed along at least a portion of a side of a ferroelectric capacitor; and

a silicon nitride layer formed over the nitrided aluminum oxide material.

5 32. A semiconductor device, comprising:
a ferroelectric capacitor formed above a semiconductor body;
an aluminum oxide material formed along at least a portion of a side of the ferroelectric capacitor;

10 a first silicon nitride layer formed over at least a portion of the aluminum oxide material; and

15 a second silicon nitride layer formed over at least a portion of the first silicon nitride layer, the second silicon nitride layer comprising a low silicon-hydrogen SiN material having an FTIR figure of merit value of about 0.05 or less, wherein the FTIR figure of merit is calculated as (Si-H absorbance) / (N-H absorbance x 1.4).

33. The semiconductor device of claim 32, wherein the low silicon-hydrogen SiN material has an FTIR figure of merit value of about 0.04 or less.

20 34. The semiconductor device of claim 32, wherein the low silicon-hydrogen SiN material has an FTIR figure of merit value of about 0.03 or less.

35. The semiconductor device of claim 32, wherein at least a portion of the oxide material is nitrided.

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36. A hydrogen barrier for protecting ferroelectric capacitors in a semiconductor device, comprising:

an aluminum oxide material formed along at least a portion of a side of a ferroelectric capacitor;

a first silicon nitride layer formed over at least a portion of the aluminum oxide material; and

- a second silicon nitride layer formed over at least a portion of the first silicon nitride layer, the second silicon nitride layer comprising a low silicon-hydrogen SiN material having an FTIR figure of merit value of about 0.05 or less, wherein the FTIR figure of merit is calculated as (Si-H absorbance) / (N-H absorbance x 1.4).
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